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OBSERVATIONS ON POLYCYSTID GREGARINES  
FROM ARTHROPODA \*

MINNIE E. WATSON

The following pages contain observations on already known and new species obtained by the writer chiefly during the past summer.

*BULBOCEPHALUS WARDI nov. gen., nov. spec.*

[Figures 1, 2, and 3]

Host: Clerid larva (Det. E. P. Felt)

Habitat: Intestine

Location: Oyster Bay, Long Island, June, 1916

Fifty or more specimens of this gregarine, mostly free trophozoites, were taken from a single Clerid larva. The sporonts are solitary and rather small, and the species is characterized chiefly by the distinct bulb in the mid-region of the large epimerite of the trophozoite.

The longest sporont seen measured  $190\mu$  in length and  $45\mu$  in width. One trophozoite exceeded in length the longest sporont, being  $290\mu$  in length. The protomerite of the sporont is slightly longer than wide, broadly rounded in front, and slightly constricted at the septum. The deutomerite is widest at the "shoulder" and tapers from thence, ending in a long blunt-pointed extremity. The average ratio of length of protomerite to total length is about 1:5; the protomerite and deutomerite are of approximately the same width.

The epimerite is unique. It consists of three parts: *a*, a broad base fitting on the apex of the protomerite, tapering at the top to form a neck; *b*, a spherical bulb, in the middle; *c*, a stout style at the apex. In other words, the epimerite consists of a stout broad-based style, bulbous in the middle. In length, it measures one-fifth to one-third the total length of the trophozoite. Complete dimensions of several epimerites are given in the table at the end of this species.

The protoplasm is dense, rendering it dark in color in both protomerite and deutomerite. The ellipsoidal nucleus is not visible in the live sporont; when stained, it is seen to be small in the sporont (larger in comparison in the trophozoite), and lies diagonally across the largest part of the deutomerite. One karyosome is present.

The writer is unable to classify this species in any known genus. The epimerite is most nearly related to that of the genus *Stylocephalus*; in this genus it consists of a more or less long, slender neck terminating

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\* Contributions from the Zoological Laboratory of the University of Illinois under the Direction of Henry B. Ward, No. 79.

in a large or small papilla. There may or may not be a bulbous base. The nucleus is ellipsoidal. The type species of the genus is *Stylocephalus oblongatus* (Hammerschmidt) Watson, see Watson 1916: 159.

The present specimens differ from the type species of the aforesaid genus in but one respect: The bulbous papilla of the epimerite is placed not at the apex of the cylindrical neck, but at its mid-point. In no species of the named genus is there a papilla at other than the apex. It therefore devolves upon the writer to describe a new genus in order to place the specimens found. I therefore designate it *Bulbocephalus*, and place it as follows:

Family Stylocephalidae Ellis. Sporonts solitary, epimerites varied. Nucleus ovoidal. Dehiscence by pseudocyst. Spores irregularly shaped, brown or black, in chains (Watson 1916: 47).

Type Genus *Stylocephalus* Ellis. Epimerite a dilated papilla at the end of a long slender neck. Cyst covered with small papillae and indentations. Spores hat-shaped.

New Genus *Bulbocephalus*. Epimerite a dilated papilla placed in the middle of a rather long slender neck. Cyst and spores unknown.

The species is named for Professor Henry B. Ward of the University of Illinois.

A table of typical measurements, in microns, is given herewith:

Length epimerite .....	60	x	x	40	30
Length protomerite (without epimerite) .	50	30	40	15	20
Length deutomerite .....	180	62	30	55	40
Total length sporont.....	290	192	170	110	90
Width epimerite .....	16	x	x	16	10
Width protomerite .....	42	32	40	20	18
Width deutomerite .....	37	45	40	28	31
Ratio length prot. (without epim.):					
total length .....	1:5.8	1:6.4	1:4.2	1:7	1:4.5
Ratio width prot.: width deut.....	1.1:1	1:1.4	1:1	1:1.4	1:1.7
Diameter nucleus .....			8x15		11x27

*BULBOCEPHALUS ELONGATUS nov. spec.*

[Figures 4, 5, and 6]

Host: *Cucujus* larva (Det. Adam Boving)

Habitat: Intestine

Location: Oyster Bay, Long Island, August, 1916

Specimens of this peculiar gregarine were very abundant in the one beetle larva obtained. The sporonts are relatively very long and slender, unlike those of any gregarine before taken by the writer. The maximum length recorded for a sporont is  $600\mu$ ; the maximum width,  $50\mu$ . The ratio of length of protomerite to total length is 1:11, and the ratio of width of protomerite to width of deutomerite about 1:1.

The protomerite is widest near the septum, at which there is a slight constriction, and the deutomerite is widest at the "shoulder," gradually tapering from thence to form a very long posterior extremity. The protoplasm is dense in the sporont, but much less so at the posterior

end, and the nucleus is obscured in the adult. In the trophozoite, it is seen to be small and ellipsoidal and placed diagonally to the long axis of the animal.

The epimerite is a rather long, stout style dilated in the middle to form a good sized papilla. The shape of the epimerite indicates that this species is closely allied to the preceding, and is therefore placed in the new genus, *Bulbocephalus*.

A table of a few measurements in microns follows:

Length epimerite .....	x	x	40
Length protomerite (without epimerite). . .	47	30	20
Length deutomerite .....	553	300	170
Total length sporont.....	600	330	230
Width epimerite .....	x	x	10
Width protomerite .....	35	40	20
Width deutomerite .....	30	50	23
Ratio length prot.: total length.....	1:13	1:11	1:11
Ratio width prot.: width deut.....	1.1:1	1:1.2	1:1.1
Diameter nucleus .....	.....	.....	5x11

*PYXINIA BULBIFERA* nov. spec.

[Figures 7, 8, 9, 10, 11 and 12]

Host: *Dermestes lardarius* Linn. (Det. E. P. Felt)

Region of infection: Mid-intestine

Location: Oyster Bay, Long Island, May, 1916

Fifty or more specimens of this parasite were taken from one adult larder beetle, many of them being free trophozoites.

The sporonts are solitary and long and slender in shape, except at the "shoulder," where they are appreciably wider (Figs. 7 and 8). The largest sporont seen measured  $850\mu$  long and  $160\mu$  wide; the smallest specimen without an epimerite,  $600\mu$  long. The average ratio of length of protomerite to total length of sporont is 1:5, and the ratio of width of protomerite to width of deutomerite is 1:1.3.

The protomerite is generally of the same width as height, infrequently a little wider than high. It is bluntly cone-shaped, the widest portion lying two-thirds the distance from the apex, being constricted below this to meet the septum. There is often a slight indentation at the apex, left by the dropping off of the epimerite. The epicyte forms a very thick layer over the end of the protomerite (Fig. 9).

The epimerite consists of two parts, a stout bulbous crenulate and crateriform base and a short thick style. The bulbous base was frequently seen to expand and contract with considerable force by means of longitudinal folds which open and collapse, the motion of the myonemes probably forcing protoplasm in and out of the epimerite from the protomerite (Figs. 10, 11 and 12). The epimerite measures from  $60\mu$  to  $100\mu$  in length on large free trophozoites. The largest epimerite seen measured as follows: Style,  $70\mu$  long and  $10\mu$  wide at its base; bulb  $30\mu$  high and  $35\mu$  wide at its widest part.

The deutomerite tapers gradually from the "shoulder," ending in a blunt point.

The protoplasm is dense in most parts of the body. The widest portion of the deutomerite is very dark brown, nearly black, the posterior end being lighter in color. The protoplasm gradually becomes less dense in the latter region and the granules cease entirely some distance before the end is reached. The protomerite is tan in color and the epimerite transparent.

The nucleus is scarcely visible in an unstained sporont, but in stained specimens is seen to be an ellipsoidal body lying always at right angles to the main axis of the body and never diagonally, as is often the case in gregarines. A single large karyosome is present. The nucleus measured in a trophozoite about 90 by 40 $\mu$ .

Myonemes were visible at the end of the deutomerite and in the protomerite with a magnification of 490; longitudinal striations were seen with a magnification of 770 and intense transmitted light. Brownian movement was noted where the protoplasm was least dense, viz., at the apex of the protomerite and the tip of the deutomerite.

Neither cysts nor spores were seen.

Although species of the genus *Pyxinia* have been described from the genus *Dermestes*, the present specimens do not fit any of these descriptions. They differ from *Pyxinia rubecula* Hammerschmidt (Léger, 1892: 140) chiefly in shape of the epimerite, which in the latter species is urn-shaped with a wide mouth and a crenulate periphery, and with a short style. Léger's figure for an epimerite of this species indicates the diameter of the urn to be five times its depth and the minute style so short that it scarcely projects beyond the rim. The present specimens indicate an urn narrower at the periphery than elsewhere and a style nearly as wide at its base as the encircling crenulate rim. In shape and proportions, the two species compare favorably, and the host is a beetle of the same genus, although previously described from Europe.

The conspicuous refractile pyxinin crystals of *P. crystalligera* Frenzel (1892: 314) are lacking in the present species, and the long, slender sporonts with bulbous protomerites contrast strongly with the species described above. Maximum length of sporonts and shape of the epimerite are similar in the two.

The other two described species of *Pyxinia*, *P. frenzeli* Laveran and Mesnil, and *P. möbuszi* Léger and Duboscq (Watson, 1916: 151) are radically different from this species in size and shape of the sporonts and in the character of the epimerite.

Dimensions of a number of typical specimens are appended herewith, measurements being in microns:

Length epimerite .....	x	x	40	x	100
Length protomerite (without epimerite) ..	150	150	150	160	140
Length deutomerite .....	700	690	600	580	500
Total length .....	850	840	750	740	640
Width protomerite .....	150	150	140	110	120
Width deutomerite .....	160	200	190	150	150
Ratio length prot. (without epim.):					
total length .....	1:5.6	1:5.6	1:5	1:4.6	1:4.6
Ratio width prot.: width deut.....	1:1	1:1.3	1:1.3	1:1.3	1:1.2
Diameter nucleus .....					90x40

GREGARINA NEGLECTA *nov. spec.*

[Figures 13, 14, 15, and 16]

Host: *Ceuthophilus neglectus* Scudder (Det. A. N. Caudell)

Habitat: Intestine

Location: Oyster Bay, Long Island, August, 1916

Four associations of this gregarine were found in the mid-intestine of one specimen of this camel cricket. Although very similar to many other species of the genus *Gregarina* in shape, this species may be characterized by a papillate protomerite in the primate and a perfectly egg-shaped satellite, there being no constriction at the septum.

The associations seen were all of about the same length, the maximum length of an association being  $900\mu$ ; that for a single sporont  $500\mu$ . The maximum width measured was  $230\mu$ . In every instance, the primate was longer than the satellite, maximum length of the satellite being  $430\mu$ . The average ratio of length of protomerite to total length of the primate is 1:6; for the satellite the average is about 1:8.

The primate is elongate-ellipsoidal in shape and the satellite ovate, widest anteriorly. The protomerite of the primate is broadly rounded, widest at the base and papillate at the apex; it is approximately one and two-thirds times as wide as high. There is a slight constriction at the septum. The deutomerite is regularly ellipsoidal, terminating in a broadly rounded extremity.

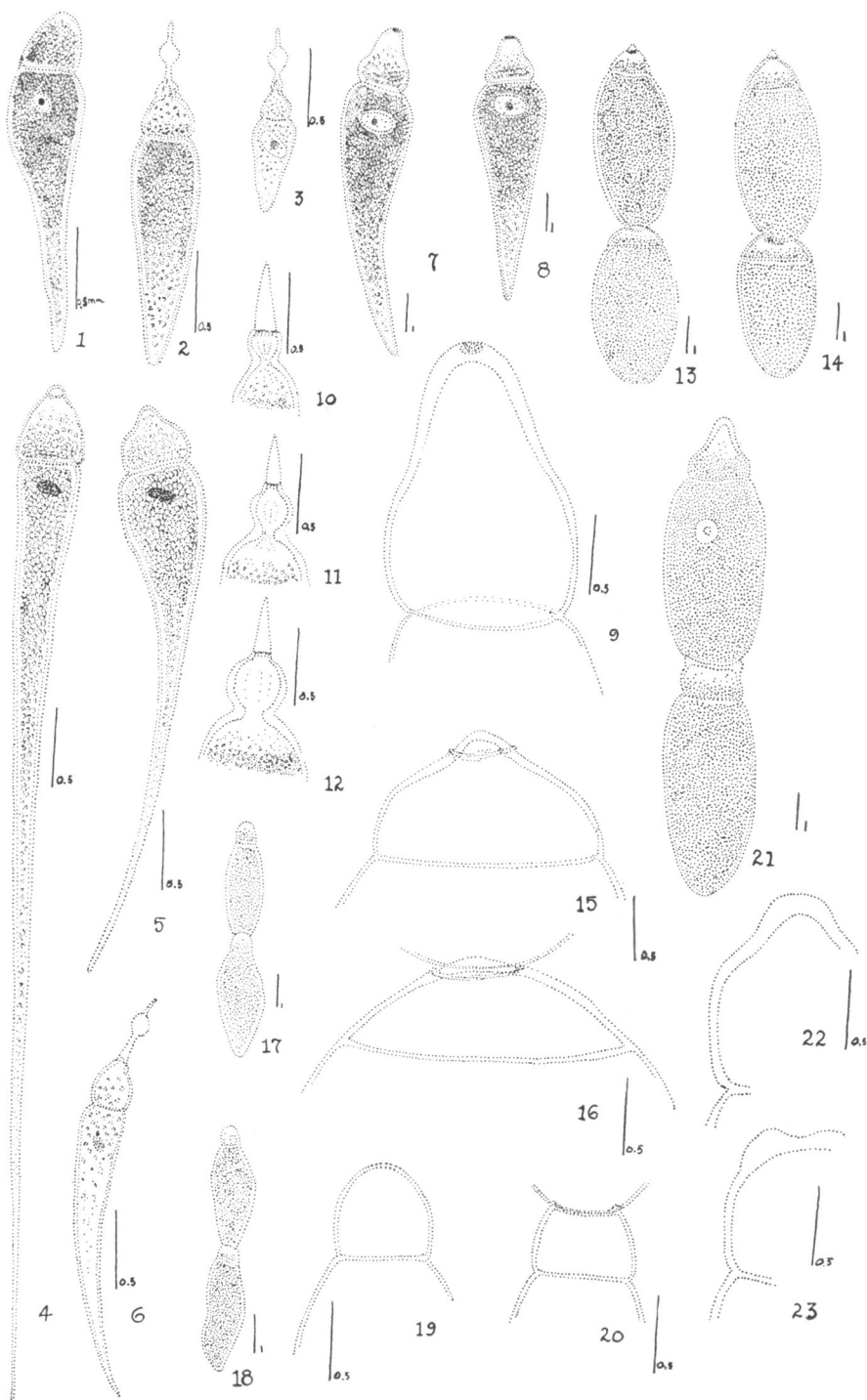
The protomerite of the satellite is very broadly rounded anteriorly, but with a trace of the papilla so prominent in the primate. It is three times as wide as high and is widest at the septum; there is no constriction at the septum. The deutomerite is widest near the middle and terminates in an extremity less well rounded than in the primate.

This species is very dark brown in color with the protomerite slightly less dense. In the satellite, both protomerite and deutomerite are very dark, rendering the septum difficult to trace. The nucleus is completely obliterated in the living animal. The epicyte is very thin, much less so than is usual with this genus.

## EXPLANATION OF PLATE

- Fig. 1.—Sporont of *Bulbocephalus wardi*.  
Fig. 2.—Large free trophozoite of *B. wardi*, with epimerite.  
Fig. 3.—Smaller trophozoite of *B. wardi*.  
Figs. 4, 5.—Sporonts of *Bulbocephalus elongatus*.  
Fig. 6.—Free trophozoite of *B. elongatus*.  
Figs. 7, 8.—Sporonts of *Pyxinia bulbifera*.  
Fig. 9.—Protomerite of *P. bulbifera*, to indicate thickening of epicyte and indentation left by epimerite.  
Fig. 10.—Epimerite of *P. bulbifera*, not expanded.  
Fig. 11.—Epimerite of *P. bulbifera*, with bulb partially expanded.  
Fig. 12.—Epimerite of *P. bulbifera*, bulb fully expanded.  
Figs. 13, 14.—Two associations of *Gregarina neglecta*.  
Fig. 15.—Protomerite of primate of *G. neglecta*, to indicate papillate apex and thickening of epicyte.  
Fig. 16.—Protomerite of satellite of *G. neglecta*.  
Figs. 17, 18.—Two associations of *Gregarina polymorpha*.  
Fig. 19.—Protomerite of primate of *G. polymorpha*.  
Fig. 20.—Protomerite of satellite of *G. polymorpha*.  
Fig. 21.—Association of *Gregarina blattarum*.  
Fig. 22.—Protomerite of primate of *G. blattarum*, to show thickening of epicyte at apex.  
Fig. 23.—Protomerite of satellite of *G. blattarum*.

# PLATE





Cysts were found in three stages of development, measuring in internal diameter about  $300\mu$  (see table of dimensions). No spores were seen.

Gregarines have been described from the genus *Ceuthophilus* in three cases: two by Ellis, and one by myself (Watson, 1916: 114-5). The present species is differentiated from the first two species in shape, from the one in shapes of the two protomerites in the association, from the other in shapes of the deutomerites. It differs from the last described species in size of sporonts and cysts and in relative thickness of the epicyte, the associations of the present species being approximately three times the length of those of the species formerly described, and the cysts twice as large in the present species ( $150\mu$  and  $300\mu$  in diameter, respectively).

A table of measurements is appended, dimensions being stated in microns:

	Primate				Satellite			
	a	b	c	d	a	b	c	d
Length protomerite ....	70	100	70	70	50	40	50	60
Length deutomerite ....	430	400	390	400	350	330	370	370
Width protomerite .....	130	150	120	120	170	190	130	150
Width deutomerite .....	210	230	210	190	200	210	200	200
Total length sporont....	500	500	460	470	380	370	420	430
Ratio length prot.: total								
length .....	1:7.1	1:5	1:6.5	1:6.7	1:7.6	1:9.2	1:8.4	1:7.1
Ratio width prot.: width								
deut. ....	1:1.5	1:1.5	1:1.7	1:1.6	1:1.2	1:1.1	1:1.5	1:1.3
Total length association.	880	870	880	900				
Diameter cysts:								
Without envelope...	300	310	290					
With envelope.....	none	470	none					

GREGARINA POLYMORPHIA (Hammerschmidt) Stein

[Figures 17, 18, 19, and 20]

Host: Larva of a Tenebrionid, probably *T. molitor*

Region of infection: Intestine

Location: Oyster Bay, Long Island, August, 1916

One specimen of this Tenebrionid beetle larva from a meal sack was found to contain half a dozen associations of one of the gregarines.

The specimens are characterized by a regularly curved protomerite in the primate and a protomerite of the same shape, but slightly flattened, in the satellite.

The sporonts vary in length from  $280\mu$  to  $320\mu$ , in width from  $100\mu$  to  $120\mu$ . The ratio of length of protomerite to total length of sporont is approximately 1:7 for both primate and satellite; the ratio for width of protomerite to width of deutomerite is about 1:2.

The sporonts are small, elongate ellipsoidal with a relatively small protomerite. The protomerite is beautifully rounded in outline in the primate, representing about two-thirds of a sphere. The widest part

is just below the middle, and there is a distinct constriction at the septum. The protomerite of the primite is approximately as wide as high; while that of the satellite, which is the same shape but flattened at the apex, is wider than high. The deutomerite is widest at about its mid-region, tapering anteriorly to the septum and posteriorly, ending in a long blunt cone.

The protoplasm in the sporont is abundant, rendering it dark brown, almost black in the deutomerite and dark tan in the protomerite. No nucleus is visible in either member of the adult association. The ectosarc is especially thin, even at the tip of the protomerite and at the septum, causing rupture to be easily effected in water, an unnatural medium.

The animals are relatively active in movement, both of progression and contortion.

Neither cysts nor spores were seen.

This species has been described from Europe and Japan, but not heretofore from the United States. The first mention of the species was made in 1838 by Hammerschmidt, and it has been seen at various times since then, by Stein, Frantzius, Schneider, Léger and Duboscq, Ishii, etc.; see Watson, 1916:172, for correlations and references. No two descriptions and drawings tally exactly, but there is not sufficient evidence to differentiate the observations into separate species. The present detailed description for a known species is given because here also are indicated variations from the original of Hammerschmidt, and since the specimens seen by every worker differ slightly from those of the others, it does not seem wise even to describe a new variety.

A table of a few typical measurements follows, dimensions being in microns:

	Primite				Satellite			
	a	b	c	d	a	b	c	d
Length protomerite .....	60	40	40	40	40	40	40	40
Length deutomerite .....	250	270	240	280	280	280	240	270
Width protomerite .....	60	50	50	40	70	60	40	60
Width deutomerite .....	110	110	100	120	120	110	100	120
Total length sporont....	310	310	280	320	320	320	280	310
Total length association.	630	630	560	630				
Ratio length prot.: total								
length .....	1:5.1	1:7.7	1:7	1:8	1:8	1:8	1:7	1:7.7
Ratio width prot.: width								
deut. ....	1:1.8	1:2.2	1:2	1:3	1:1.7	1:1.8	1:2.5	1:2

GREGARINA BARBARARA Watson 1915

This species was found at Oyster Bay, Long Island, in *Adalia bipunctata* in June, 1916. This, our commonest lady beetle in the East, was examined frequently throughout the year, but was found parasitized but once. Two associations and half a dozen isolated sporonts

were found. This species has heretofore been recorded from an unidentified *Coccinella*, not the present species.

A few measurements, in microns, are appended to supplement those already given (Watson, 1915:31 and 1916:185), and for sporonts somewhat smaller than those previously described.

	Primite				Satellite
	a	b	c	d	a
Length protomerite .....	20	30	20	20	8
Length deutomerite .....	80	70	70	80	52
Width protomerite .....	30	30	30	30	30
Width deutomerite .....	55	60	45	55	40
Total length sporont.....	100	100	90	90	60
Total length association.....	160				
Ratio length prot.: total length.....	1:5	1:3.3	1:4.5	1:5	1:7.5
Ratio width prot.: width deut.....	1:6	1:2	1:1.5	1:1.6	1:1.3
Diameter nucleus .....	....	12			

GREGARINA BLATTARUM Siebold

[Figures 21, 22, and 23]

Host: *Blatta orientalis* Linn

Regions of infection: Intestine and rectum

Location: Urbana, Illinois, June, 1915

A dozen or more biassocative gregarines were found in one specimen of the Oriental cockroach, this being the greatest number found by the writer in a single host. Many roaches were examined with negative results.

The insects are also parasitized by two species of nematodes, an infusorian, and an amoeba, the last two of which were described by Leidy in 1877 and 1881.

This gregarine is characterized by long, slender sporonts, blunt at the posterior end, by a conical, or papillated, protomerite in the primite, and a broad, flattened protomerite in the satellite.

The sporonts vary in length from 510 to 1100 $\mu$ , and in width from 160 $\mu$  to 400 $\mu$ . The average ratio of length of protomerite to total length of sporont is 1:5 for the primite and 1:8 for the satellite. The protomerite of the primite is approximately two-thirds as wide as the deutomerite, that of the satellite approximately three-fourths to fully as wide as the deutomerite. The ratio in the primite of width of protomerite to width of deutomerite is about 1:1.7, in the satellite about 1:1.4.

A table of representative measurements is appended herewith.

The protomerite of the primite is bluntly pointed, the ectoplasm at the apex being a much thicker layer than elsewhere in the animal. The widest portion of the protomerite is about two-thirds of its length from the apex, and there is a slight constriction at the septum separating protomerite and deutomerite.

The deutomerite is elongate ellipsoidal, varying but little in width throughout the length, and broadly rounded at its posterior end. The end attached to the satellite is but little flattened.

The protomerite of the satellite is slightly flattened anteriorly, and there is but little or no constriction at the septum. The deutomerite is more or less irregularly shaped, ending in a rather blunt point.

The nucleus is small and spherical. It measures about  $90\mu$  in diameter in sporonts. The spherical karyosome is faintly visible.

The deutomerite of the sporonts is very dense and blackish, the protomerite slightly less dense and dark tan in color. The deutomerite is finely granular and homogeneous, and is slightly more dense in the satellite than in the primate. The nucleus was not visible in the satellite of any specimen seen. The protomerite contains large spherical masses less closely packed together than in the deutomerite.

This species was found first by Siebold in Germany, and by many subsequent workers, including Frantzius, Leidy, Schneider, Marshall, de Magalhaes, and Crawley, and from Germany, France, Brazil, and Pennsylvania (see Watson, 1916: 99-100).

The present specimens have the same general proportions as those already described, but reach a much greater length than that stated by Leidy, which is  $500\mu$  for a single sporont; no other writer has given dimensions. The specimens now described are undoubtedly closely related to the species he saw and described as *Gregarina blattae orientalis*, for he mentions the "slight papillary thickening of the integument" at the apex of the protomerite and indicates this feature in his three drawings. He does not state, however, whether or not the species is associative.

Because of the very considerable confusion surrounding this classical species in the past, it does not seem to the writer wise to add to it and describe the specimens now found as a variety of the type species when the only disparity is found in a papillate or non-papillate apex of the protomerite. A number of variations have already been described, but are now separated into species.

The measurements given below are in microns.

	Primate				Satellite			
	a	b	c	d	a	b	c	d
Length protomerite .....	120	150	160	200	60	80	100	160
Length deutomerite ....	390	720	790	900	460	750	600	870
Width protomerite .....	120	160	200	200	150	160	250	250
Width deutomerite .....	200	260	300	360	200	230	250	400
Total length sporont....	510	870	950	1100	520	830	800	1030
Ratio length prot.: total length .....	1:4.2	1:5.8	1:5.9	1:5.5	1:8.6	1:10	1:8	1:7
Ratio width prot.: width deut. ....	1:1.7	1:1.6	1:1.5	1:1.8	1:1.3	1:1.4	1:1	1:1.6
Diameter nucleus .....		90						
Total length association.	1030	1700	1750	2130				

A new place record has been established for *Leidyana erratica* (Crawley) Watson, at Douglas Lake, Michigan, by Mr. H. G. May, of the University of Illinois. This species and *Gregarina oviceps* Diesing were very commonly parasitic in the same host, which has been designated *Gryllus americanus* Blatch. Mr. May says, however, that the host may be *G. pennsylvanicus* Burm., or even an hitherto undescribed species of cricket. The cricket fits neither description perfectly.

In none of the instances recorded above was it possible to complete a life-history of the parasite because the hosts are for the most part uncommon and rarely more than one specimen of the same species was taken during the summer. It was unfortunately impossible to secure any intestines for sectioning purposes and, as cysts were rarely seen in the host parasitized, the life-histories were not carried to completion.

Type specimens of the above species have been deposited in the Ward Collection of Parasites at the University of Illinois.

#### SUMMARY

A new genus, *Bulbocephalus*, with two new species is described for the family Stylocephalidae.

New species are described for *Pyxinia* and *Gregarina*, and new data are given for Gregarines already known.

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